A framework for aligning humans, technology and organization in Industry 4.0

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A framework for aligning humans, technology and organisation in Industry 4.0

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Abstract: Overcoming human work and organisational related challenges emerging with the concept of Industry 4.0 demands new ways of incorporating Human Factors and Ergonomics throughout the different organisational levels of industrial companies. In this extended abstract, we present a framework for aligning humans, technology and organisation with the aim of ensuring human well-being and desired business outcome. The framework provides a guideline for how to incorporate Human Factors and Ergonomics from the design of a strategy concept to operations on factory shop floors. Furthermore, we use empirical data from industrial case studies to illustrate elements of the framework.

Keywords: Industry 4.0, strategy, work system

1. Introduction

The changes introduced by Industry 4.0 are creating new opportunities and challenges throughout the different organisational levels, affecting business objectives, performance and human well-being. However, because of the lack of experience and knowledge on the pertaining digital technologies, industrial companies are facing a challenge in aligning humans, technology and organisation. While the International Ergonomics Association's defines the aim of Human Factors and Ergonomics (HF/E) as to optimise human well-being and overall system performance (IEA 2018), many companies often associate HF/E solely with occupational health and safety, thus giving it low priority (Dul and Neumann 2009). To overcome this misunderstanding and to fully utilise the benefits of HF/E as defined by IEA, Dul and Neumann (2009) suggest linking HF/E to the company's strategy. This is equally important in Industry 4.0 context, where business outcomes is regarded as one of the main drivers (Müller et al. 2018)

These pertaining human work and organisational challenges demand new tools, models and frameworks that integrate business and HF/E, thus the research question of this paper, "how can industrial companies align humans, technology, and organisation in Industry 4.0 to ensure human well-being and desired business outcome?"

In this extended abstract, we present a conceptual framework for incorporating HF/E and business throughout the different organisational levels (strategic, tactical, and operational) of a company. We use examples from industrial case studies illustrate aspects of the framework.

2. Methodology

We conducted several case studies at different small, medium and large industrial companies located in Denmark that had started their industry 4.0 journey and implemented new digital technologies in their shop floor work systems. The data collection consisted of semi-structured interviews with workers and decision makers on all three organisational levels, in addition to observations and demonstrations of the new digital technologies in action. We have used the results of case studies to illustrate aspects of the framework with examples.

3. Results

The idea of the framework is to consider HF/E aspects on different organisational levels with the objective of ensuring human well-being and desired business outcome. The framework's intended users are decision makers on the three organisational levels, strategic, tactical, and operational, which we have also have specified in the framework. Refer to Figure *3* for an overview of the framework.

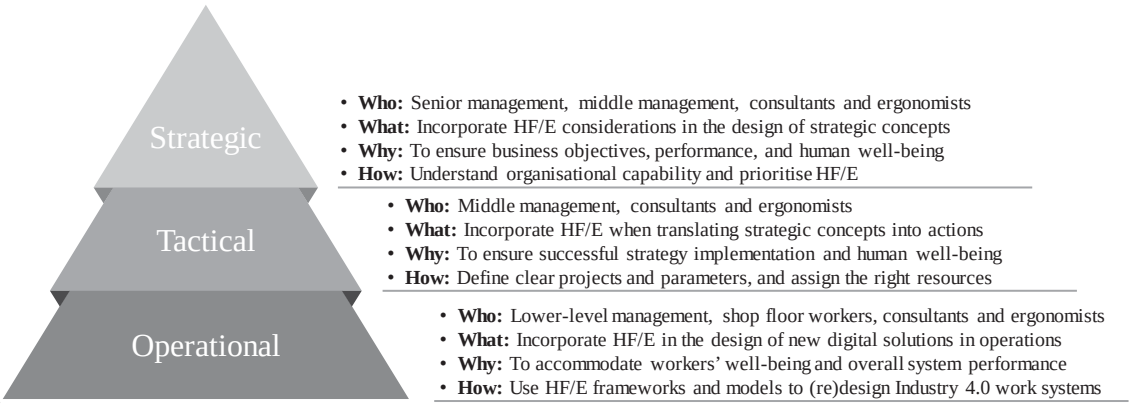

Figure 3: Framework for aligning humans, technology and organisation in Industry 4.0

3.1 Strategic

At this level, strategic decision makers should incorporate HF/E considerations when designing strategies and developing industry 4.0 related strategic concepts. Decision makers at this level might include senior management e.g. C-level executives or company owner (in SMEs) and/or middle management e.g. regional managers and plant managers as well as consultants and ergonomists. Decision makers should incorporate HF/E in their strategy to evaluate the effect of new digital solutions and compatibility between the new strategy initiatives and the company's current organisational culture, capabilities and procedures. Thus, ensuring the desired business outcomes and human well-being. Decision makers at this level, can incorporate HF/E by achieving a holistic understanding of essential organisational elements and interactions, and evaluating potential challenges. Hereafter, they can address these challenges in the company's strategy and long-term objectives and communicate them to the rest of their organisation.

In one of the case studies at a large company (>250), the strategic level decision makers had defined a strategy for the next five years that included digitalisation. In this context, they had evaluated that their staff might not have the necessary skills and competences to achieve their strategic objectives. To overcome this challenge, the decision makers had created an organisational pillar in their overall strategy, focusing on staff development and empowerment, which was the second priority (out of 6) in the company's overall strategy.

3.2 Tactical

Tactical decision makers should incorporate HF/E considerations when translating strategic level concepts and decisions into tangible solutions and actions. Tactical level decision makers might include company owner (in SMEs), middle management, and lower-level management e.g. team leaders and assistant managers as well as consultants, and ergonomists. Decision makers at this level should incorporate HF/E in their decisions to ensure successful realisation of the company's strategic concepts and HF/E considerations, thus accommodating the workers well-being and overall system performance in operations. Decision makers at this level might incorporate HF/E by defining clear parameters for the operational level decision makers e.g. allocating the right recourses, defining a clear scope, identifying cross-departmental dependencies, and providing

needed training. In addition, the decision makers should consider identify and assign operational level decision makers that are familiar with HF/E.
In one of the case studies at a large company, the tactical level decision makers had clearly defined a physical work system for a pilot project, testing a new digital solution to ensure the viability of the solution before companywide rollout. In addition, they had purposely chosen one of their internal Lean consultants to be in charge of designing the new solution because the decision makers viewed him as a young technology enthusiast whom also had an understanding of the "human-side" of the business.

3.3 Operational

Operational decision makers should incorporate HF/E when implementing new digital technologies and designing new digital solutions in operations work systems. Operational decision makers might include lower-level management, production- and production development engineers, operations level workers as well as consultants, and ergonomists. These decision makers should incorporate HF/E to design efficient work systems and accommodate workers' well-being and ensure overall system performance. Thus, creating well-functioning and human-centred solutions for operations. The decision makers at this level might incorporate HF/E by using human-centred design approaches and other HF/E frameworks and models to (re)design industry 4.0 work systems.
In one of the case studies, the operational decision makers had followed a process similar to Human Centred Design (BSI Group 2010) to redesign one of their work system in connection with the introduction of a new digital solution. They had actively involved the shop floor workers and created a continuous feedback loop to accommodate the workers and ensuring the action defined by the tactical decision makers.

3.4 Conclusion

Successful incorporation of HF/E in industry 4.0 work systems in operations require considerations and engagement from all decision making levels within a company. In this extended abstract, we presented a framework for aligning humans, technology and organisation in Industry 4.0, with the aim at accommodating human well-being and meeting desired business outcomes. The framework describes who, what, why and how in relations to HF/E considerations for each of the three organisational levels.

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